# Coastal Mixing and Optics

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## LONG-TERM GOALS

The long-term goal of this study is to relate optical and fluid dynamic processes on vertical scales of centimeters to tens of meters.

## OBJECTIVES

The objectives of this study are to address the following questions:

- Under what circumstances do the physical forcing mechanisms determine the optical properties and hence radiative transfer?
- Does mixing affect the dissolved and particulate components differently?
- Can the distribution of dissolved and particulate optical substances be used as tracers of physical processes?
- How does the size of the particles in the bottom boundary layer affect the spectral slope of the beam attenuation coefficient.

## APPROACH

During August 1996 and May 1997 we collected optical and hydrographic data at the Coastal Mixing and Optics (CMO) central site at 40.5° N 70.5° W. The data was collected with the Slow Descent Rate Optical Profiler (SlowDROP). Profiles of spectral absorption, scattering, and attenuation were obtained for both particulates and dissolved materials. Our approach is to analyze the optical and hydrographic data we collected during the two experiments, along with observations and data from other investigators. We are using the data to compare and contrast the relationships between the optical and physical properties during the spring and fall cruises as well as identifying interesting physical and optical features within each data set.

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## WORK COMPLETED

We have combined our data with that of other investigators to provide a description of the observed variability in the optical properties in the Middle Atlantic Bight ( Sosik et al., submitted;  Blakey et al., submitted; Boss et al., submitted a).

We analyzed the changes in optical properties associated with salinity intrusions that were commonly observed during the 1996 experiment (Pegau et al., submitted).

We completed an analysis of the relationships between the spectral slope of the beam attenuation coefficient and its magnitude in the bottom boundary layer (Boss et al, submitted b)

The effects of the passage of storms on the distribution of optical properties was determined  (Pegau et al., 1999b)

We participated in a workshop to determine interdisciplinary research topics based on the combined data sets of the investigators involved in the CMO project.

## RESULTS

Based on analyses performed on the 1996 and 1997 SLOWDROP data we collected during the Coastal Mixing and Optics experiments, and with the collaboration of other investigators, we obtained the following results.

- Salinity intrusions associated with a meander in the shelfbreak front were commonly observed during the 1996 experiment.  These intrusion brought clearer slope water onshore and were subject to mixing by salt fingering, diffusive convection, and possibly shear flow mixing.  The effects of the mixing on the optics are evident in property-property plots (Figure 1).  We found that the absorption coefficient of dissolved materials acted as a conservative tracer within the intrusions.  The scattering coefficient was nearly conservative, however the absorption coefficient of the particles did not change in a conservative manner. There was also some evidence of elevated levels of scattering near density interfaces.
- We have analyzed the CDOM component of the IOPs. Our data set is unique in that it resolves the whole water column, and includes both temporal (from seasonal to 10min sampling interval) and spatial information. During our analysis we have identified a bottom source of CDOM associated with sediment resuspension that, to our knowledge, has not been previously observed over the continental shelf. This affects the distribution of the absorption coefficient of dissolved materials ($a_g$).  It was determined that the short-term variability in $a_g$ was mostly due to conservative processes associated with advection ($a_g$ was nearly constant along isopycnals). Over longer time periods (days and longer), sources and sinks of $a_g$ result in a distribution that deviates from that of physical properties near the surface and near the bottom.

The value of $a_g$ in general decreases away from land and from the surface downward, this pattern is modified by photo-oxidation at the surface and a source near the bottom (Figure 2).

- Within the bottom boundary layer (BBL) the spectral shape of the beam attenuation coefficient of particles became flatter with increasing values of attenuation due to an increase in the abundance of large particles. Particle resuspension and settling in the BBL are both dependent on particle size and density. For particles of similar density resuspension and settling would result in a flattening of the particle size distribution towards the bottom. It is found that in both fall and spring the particle attenuation magnitude correlates with its spectral shape, with a flatter shape associated with higher values of attenuation (Fig. 3). This is consistent with idealized optical theory predicts that the associated change in the particle size distribution will cause a change in attenuation spectra; a flatter size distribution will be associated with a flatter attenuation spectrum. Data from a Coulter Multisizer corroborate this result as well (Boss et al, submitted b)
- Spring storms were found to redistribute the optical properties in the water column. Advection of water into the region changed the optical properties within a day after the passage of storms. Hence, the effects of storms on the distribution of optical properties are short lived because of the effects of advection.

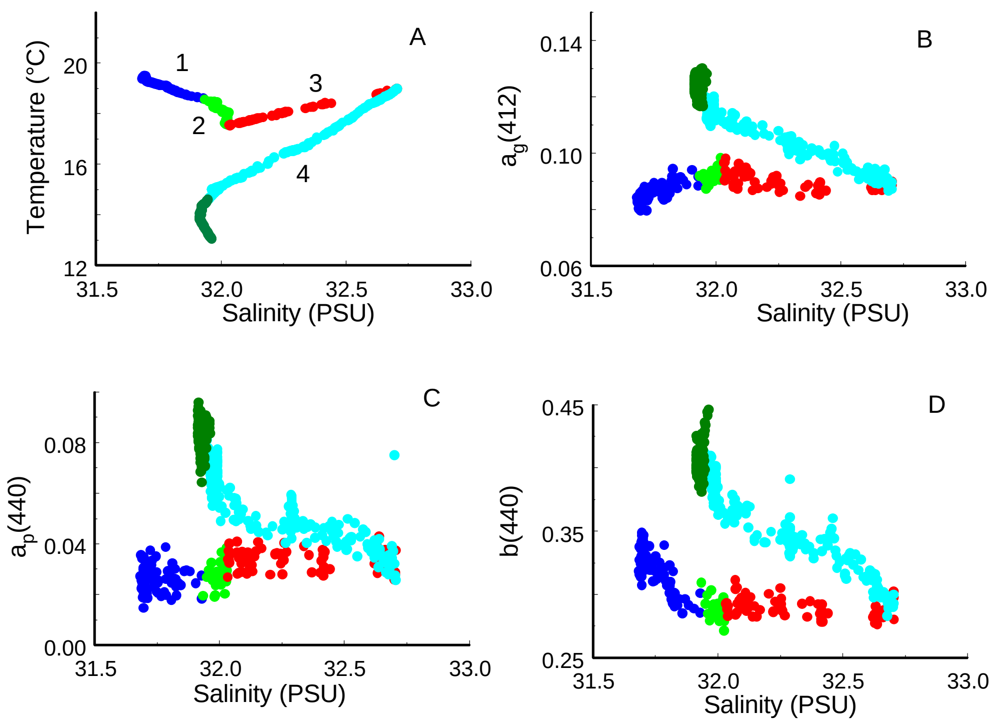


Figure 1. Regions of mixing are evident in the temperature-salinity relationships associated with a salinity intrusion. The effects of mixing on the distribution of optical properties are evident in the absorption coefficients measured at the top (1) and bottom (4) of the salinity intrusion. The scattering coefficient near the peak of the salinity

intrusion was higher than would have been predicted based on a mixing line. This is evidence that other processes are still important in determining the distribution of optical materials.

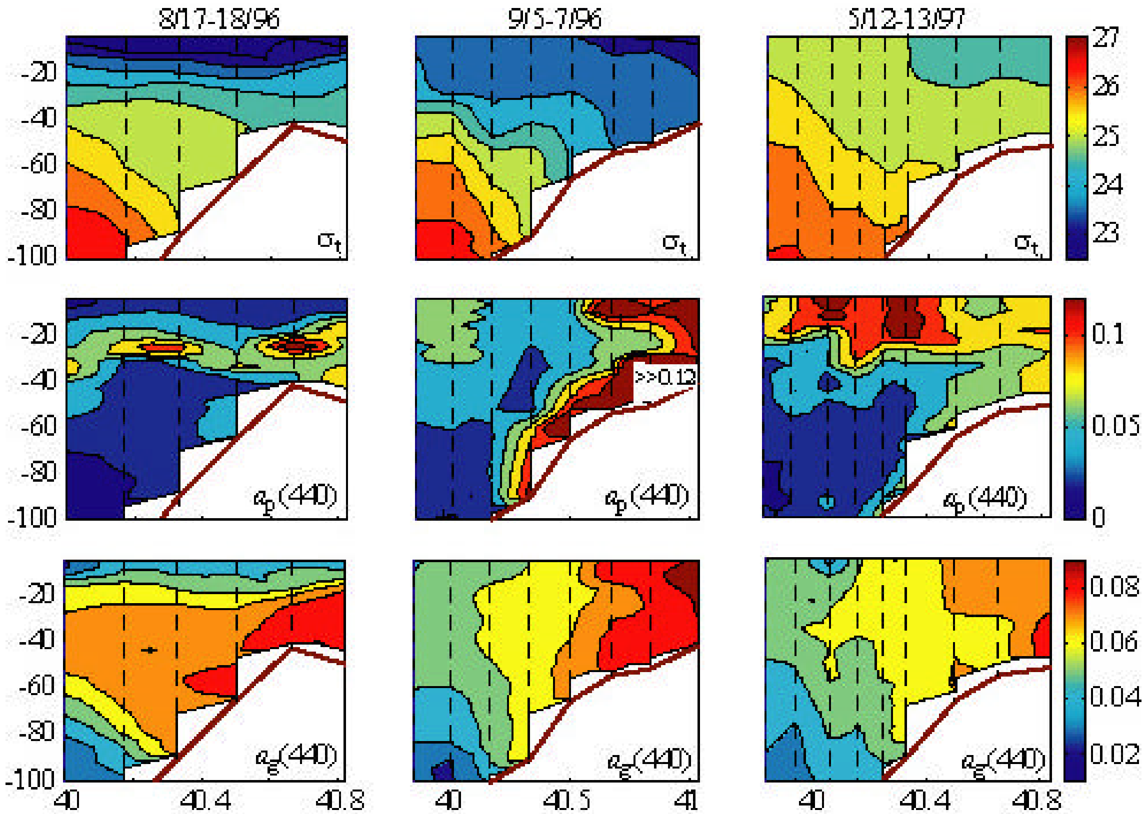


Figure 2. Horizontal sections of $\sigma_t$, $a_p(440)$, and $a_g(440)$ associated with 3 cross-shelf transects during the two CMO experiments are provided. Decreased stratification and increased $a_g$ values are observed after the passage of Hurricane Edouard (second set of panels). The increase in $a_g$ values towards shore represent increased mixing of a bottom source of colored dissolved organic materials as the water depth decreases. Similar results are observed in the spring when storms are common in the region. The broken lines denote the location of sampling stations.

## IMPACT/APPLICATIONS

The absorption coefficient of particles can change rapidly making it a poor tracer of water movement. The scattering by particles was more conservative within the intrusions. The absorption by dissolved materials acted as the most conservative tracer of mixing. This is not surprising since the intrusions occurred at a depth where there were no major source or sinks of dissolved organics. The time scales important for modeling the changes in optical properties are therefore smallest for particulate absorption.
The analysis shows that resuspension of bottom sediments by storms can introduce higher levels of colored dissolved organic material within the water column. Unlike the particles that settle back to the bottom the dissolved material will remain in suspension

affecting the optical properties, and the performance of optical systems, for longer time periods. The resuspended particles tended to have a clear relationship between the magnitude of their beam attenuation coefficient and the spectral slope of the attenuation coefficient.

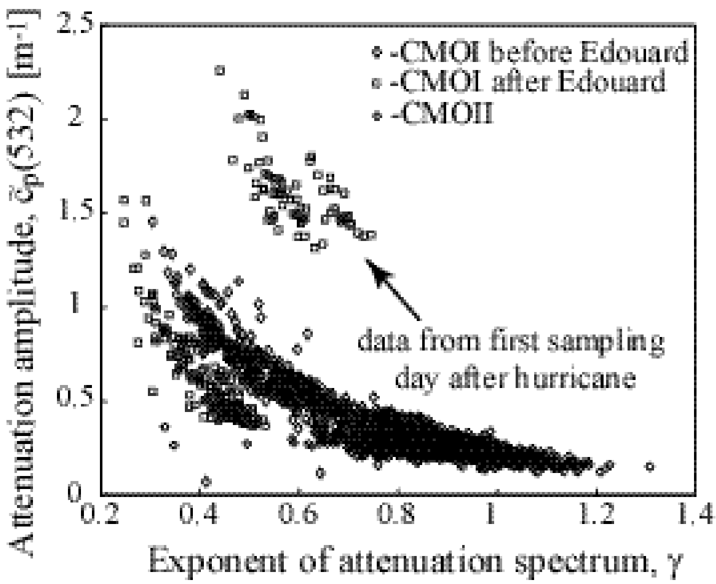


Figure 3. Particulate attenuation vs. its hyperbolic slope measured within the BBL during the two CMO sampling seasons. Both were derived by least-square fitting the particulate attenuation to: $c_p = \tilde{c}_p(532)\left(l/532\right)^{-g}$ .

**TRANSITIONS**

Our data has been supplied to all investigators in the Coastal Mixing and Optics program that has expressed an interest in the data. It is being used by Dr. Sosik at WHOI, and Dr. Gardner at TAMU to provide detailed vertical structure of inherent optical properties and to provide a more comprehensive physical and optical time series of the region.

Data from these experiments were included in a study the spectral characteristics of the inherent optical properties at several locations (Barnard et al, 1998). This study showed that many of the spectral characteristics were similar between locations. The data was also used in closure of the inherent and apparent optical properties using a backscattering independent model ( Barnard et al., 1999)

**RELATED PROJECTS**

None

## REFERENCES

Barnard, A. H., W. S. Pegau, and J. R. V. Zaneveld, 1998, Global relationships of the inherent optical properties of the oceans, J. Geophys. Res., vol. 103, pp 24,955-24,968.

Barnard, A. H., J. R. V. Zaneveld, and W. S. Pegau, 1999, In situ determination of the remotely sensed reflectance and the absorption coefficient: closure and inversion, Appl. Opt., vol. 38, pp. 5108-5117.

Pegau, W. S., E. Boss, A. H. Barnard, and J. R. V. Zaneveld, The redistribution of optical properties during storms in the Mid-Atlantic Bight, Presented at ASLO 1999.

## PUBLICATIONS

J. C. Blakey, W. D. Gardner, I. D. Walsh, M. J. Richardson, S. Pegau, J. R. V. Zaneveld, C. Roesler, M. Gregg, J. MacKinnon, H. Sosik, and A. J. Williams, III, Stratification, storms, particles, and optics during the late summer and spring on the New England continental shelf, submitted to *J. Geophys. Res.*

Boss, E., W. S. Pegau, J. R. V. Zaneveld, and A. H. Barnard, Spatial and temporal variability of absorption by dissolved material on a continental shelf, submitted to *J. Geophys. Res.*

Boss, E, W. S. Pegau, W. D. Gardner, J. R. V. Zaneveld, and A. H. Barnard, Particulate attenuation at the bottom boundary layer of a continental shelf, submitted to *J. Geophys. Res.*

Pegau, W. S., J. A. Barth, and G. C. Chang, Mixing of optical properties as evidenced in salinity intrusions observed over the continental shelf in the Middle Atlantic Bight, submitted to *J. Geophys. Res.*

Sosik, H. M., R. E. Green, W. S. Pegau, and C. S. Roesler, Temporal and vertical variability in optical properties of New England shelf waters during late summer and spring, submitted to *J. Geophys. Res.*